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... THE ...

AMERICAN FERTILIZER

"That man is a benefactor to his race who makes two blades of grass to grow where but one grew before."

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Phosphate Rock Industry in 1940

FOR the second time in the history of the industry, shipments of domestic phosphate rock have reached the 4-million-ton mark. Total shipments in 1940, as reported by American producers to the Bureau of Mines, United States Department of the Interior, were 4,002,700 long tons valued at $12,334,662, an increase over 1939 of nearly a quarter of a million tons or 7 per cent, but short of the 1920 record peak by about 100,000 tons. Mine output likewise passed the 4-million-ton mark, exceeding 1939 but considerably below the 4,261,416 ton peak of 1937. Domestic demand for phosphate rock in 1940 jumped 16 per cent over that of 1939, an increase of 442,597 tons, far more than counterbalancing the 21 per cent decrease, or nearly 200,000 tons, in exports which declined to only 751,495 tons. Imports of phosphate rock were restricted to 2,953 long tons from Curacao. No apatite was

Salient Statistics of the Phosphate Rock Industry in the United States, 1939-40

	1939			1940		
		Value at Mines			Value at Mines	
	Long Tons	Total	Average	Long Tons	Total	Average
Production (mined)	3,987,970	(1)	(1)	4,068,077	(1)	(1)
Sold or used by producers:						
Florida:						
Land pebble[2]	2,547,782	$7,353,567	$2.89	2,780,800	$7,538,316	$2.71
Soft rock	41,906	128,435	3.06	41,845	102,508	2.45
Hard rock	89,096	411,455	4.62	22,367	100,353	4.49
Total, Florida	2,678,784	7,893,457	2.95	2,845,012	7,741,177	2.72
Tennessee[2, 3]	938,448	3,856,505	4.11	994,361	3,967,043	3.99
Idaho	95,451	431,938	4.53	99,088	441,598	4.46
Montana	44,384	112,142	2.53	64,239	184,844	2.88
Virginia	(3)	(3)	(3)	(3)	(3)	(3)
Total, United States	3,757,067	12,294,042	3.27	4,002,700	12,334,662	3.08
Imports	3,500	[4]23,625	[4]6.75	2,953	[4]19,536	[4]6.62
Exports[5]	949,006	[6]5,233,104	[6]5.51	751,495	[6]3,845,495	[6]5.12
Apparent consumption[7]	2,811,561	....	....	3,254,158	....	....
Stocks in producers' hands, Dec. 31:						
Florida	1,504,000	(1)	(1)	1,420,000	(1)	(1)
Tennessee[2, 3]	247,000	(1)	(1)	268,000	(1)	(1)
Other	2,000	(1)	(1)	3,000	(1)	(1)
Total stocks	1,753,000	(1)	(1)	1,691,000	(1)	(1)

[1] Figures not available.
[2] Includes sintered matrix.
[3] Virginia included with Tennessee.
[4] Market value (or price) at port and time of exportation to the United States.
[5] Excludes sintered matrix.
[6] Value at port of exportation.
[7] Quantity sold or used by producers plus imports minus exports.

imported during the year. Early in 1941 phosphate rock exports to many countries were placed under export-license control.

Trade journal prices for various grades of domestic phosphate rock were unchanged in 1940. Florida land pebble, 68 per cent B.P.L., continued at $1.90; 70 per cent grade at $2.15; 72 per cent grade, $2.40; and the 75 per cent grade at $2.90. Florida high-grade hard rock quotation remained at $4.35 and Tennessee quotations at $4.50 for the 72 per cent grade and $5.50 for the 75 per cent grade.

Phosphate rock was mined in Florida, Tennessee, Idaho, and Montana, and apatite in central Virginia.

Florida

Total shipments of phosphate rock from Florida in 1940 were 6 per cent greater in quantity, but 2 per cent less in value than in 1939. Land pebble showed an increase of 9 per cent in tonnage sold or used in 1940 over 1939 and also increased in value. Soft rock shipments were virtually the same in both years, but dropped considerably in value. Hard rock shipments declined 75 per cent with a decrease in value from $411,455 in 1939 to $100,353 in 1940. No hard rock phosphate mining operations were in progress in Florida in 1940, all shipments being made from stocks. Shipments of sintered phosphate matrix from Pembroke, Florida, to Europe were smaller than in 1939. Total stocks of Florida phosphate rock in the hands of producers were lower at the end of 1940 than on December 31, 1939.

Tennessee

The tonnage of phosphate rock sold or used by producers in Tennessee plus a small quantity of apatite from Virginia topped the previous all-time high of 1939 by 6 per cent, falling just short of one million tons. No blue or white phosphate rock was marketed in 1940. That shipped was all brown rock. Stocks of phosphate rock in the hands of the producers at the close of 1940 were larger than on December 31, 1939.

The T. V. A., according to its annual report, produced in the fiscal year ending June

Phosphate Rock Sold or Used by Producers in the United States, 1939-40, by Grades, Uses, and Classes of Consumers

	1939		1940	
	Long Tons	Value	Long Tons	Value
Grades—B.P.L.[1] Content (per cent):				
Below 60	395,709	(2)	347,696	(2)
60 to 66	18,818	(2)	55,359	(2)
68 basis, 66 minimum	356,512	(2)	357,983	(2)
70 minimum	383,483	(2)	339,744	(2)
72 minimum	1,227,806	(2)	1,390,284	(2)
75 basis, 74 minimum 75 minimum	769,360	(2)	936,309	(2)
77 basis, 76 minimum 77 minimum	328,784	(2)	328,628	(2)
Above 85 (apatite)	(3)	(2)	(3)	(2)
Undistributed[4]	276,595	(2)	246,697	(2)
	3,757,067	$12,294,042	4,002,700	$12,334,662
Uses:				
Domestic:				
Superphosphates	2,192,779	(2)	2,564,844	(2)
Phosphates, phosphoric acid and ferrophosphorus	479,020	(2)	532,980	(2)
Direct application to soil	95,667	(2)	106,292	(2)
Fertilizer filler	30,994	(2)	32,804	(2)
Stock and poultry feed	1,794	(2)	1,311	(2)
Undistributed[5]	10,423	(2)	6,747	(2)
Exports[6]	946,390	$3,747,608	757,722	$2,995,591
	3,757,067	$12,294,042	4,002,700	$12,334,662
Classes of Consumers:				
Affiliated companies	948,640	$3,035,268	1,089,045	$2,961,334
Other domestic consumers	1,862,037	5,511,166	2,155,933	6,377,737
Exports[6]	946,390	3,747,608	757,722	2,995,591
	3,757,067	$12,294,042	4,002,700	$12,334,662

[1] Bone phosphate of lime.
[2] Figures not available.
[3] Included under "Undistributed"; Bureau of Mines not at liberty to publish figures.
[4] Includes grades B.P.L. content between 68 and 70; 69/66; 71; 73; 73.8; 74.8; 76; 76.55; 78; 78/76; and above 85 per cent; also ground phosphate rock and dust, B.P.L. content not known.
[5] Includes some calcined phosphate and phosphatic material used in pig-iron blast furnaces, concrete aggregates, and in the manufacture of concentrated fertilizers.
[6] As reported to the Bureau of Mines by producers (exclusive of exports by dealers, etc.).

30, 1940, about 80,000 tons of concentrated superphosphate and shipped 82,000 tons. More than 4,000 tons of calcium metaphosphate were produced and close to 8,000 tons were shipped. Fused phosphate rock, potassium metaphosphate, and potassium calcium metaphosphate were produced in limited quantities for experimental tests. Raw rock for making elemental phosphorus was obtained both from the Florida land-pebble field and from the Tennessee brown-rock field. Additional purchases of phosphate lands were made during the fiscal year and seven tracts in Maury County were sold to the Monsanto Chemical Company. Holdings of phosphate lands as of June 30, 1940, approximated 2,900 acres, and contained 16,000,000 tons of phosphate rock matrix. Construction of a large washing and processing plant near Godwin, Tenn., has been started.

Six phosphate rock mining companies produced 96 per cent of the entire phosphate rock production of Tennessee in 1940. The Monsanto Chemical Co. added to its phosphate rock holdings in Tennessee, and also placed in operation early in January, 1941, a fourth electric furnace for the production of elemental phosphorus from Tennessee brown rock phosphate. The Federal Chemical Co. and the Charleston Mining Co. are reported to have completed remodelling of their plants. The Hoover & Mason Co. began extensive alterations in the method of feeding phosphate rock to their washing plant. The Victor Chemical Works did no actual mining of phosphate rock, purchasing all its requirements of Tennessee brown rock. In August, 1940, it began the construction of a fourth electric furnace at its Mt. Pleasant plant.

Western States

Idaho and Montana were as usual the only Western States that produced phosphate rock in 1940. The Anaconda Copper Mining Co. operated its No. 3 mine at Conda, Caribou County, Idaho. In Montana there were two producers. The Montana Phosphate Products Co. of Trail, British Columbia, the larger of the two, operated the Anderson and Graveley mines and some United States Government leases near Garrison, Mont., supplying the requirements of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail. The Mineral Hill Mining Co. shipped several thousand tons of phosphate rock from near Avon, Powell County, Mont., to the Anaconda Copper Mining Co. at Anaconda, Mont.

Virginia

Apatite-bearing titanium ore was mined by the Southern Mineral Products Corporation, a subsidiary of the Vanadium Corporation of America, in Amherst County, Va., and milled at its plant at Piney River, Va.

PYRITES IN 1940

Domestic production of pyrites (ores and concentrates) reached a new record in 1940, according to the Bureau of Mines, Department of the Interior. Output rose to 617,513 long tons, containing 41.7 per cent sulphur, valued at approximately $1,892,000 in 1940. Of the 1940 total, 422,092 long tons were consumed by the producing companies and 196,015 tons were sold, compared with 323,027 tons and 188,712 tons, respectively, in 1939. Ninety-two per cent of the output was classified as fines and the remainder lump, the bulk of the former being flotation concentrates.

Tennessee had the largest production of pyrites in 1940; other producing States were California, Colorado, Illinois, Indiana, Mis-

Salient Statistics of the Superphosphate Industry in the United States, 1937-40

		1937	1938	1939	1940
Production[1]:					
Bulk superphosphate	short tons	4,429,767	3,575,588	3,801,194	4,385,971
Wet base and wet mixed goods	short tons	122,680	156,730	152,500	136,204
Shipments[1]:					
All superphosphate, to consumers	short tons	1,046,334	902,490	897,749	1,048,508
All superphosphate, to others	short tons	2,130,860	1,817,293	2,073,123	2,252,620
Base and mixed goods[2]	short tons	1,723,590	1,537,491	1,526,026	1,519,493
Stocks in manufacturers' hands Dec. 31[1]:					
Bulk superphosphate	short tons	1,313,327	1,361,127	1,233,297	1,285,408
Bases and mixed goods[2]	short tons	784,532	669,503	701,649	740,914
Exports of superphosphate[3]	long tons	78,949	90,237	95,224	141,289
Imports of superphosphate[3]	long tons	57,930	18,753	17,238	10,017
Sales of phosphate rock by producers for superphosphate production	long tons	2,391,245	2,074,779	2,192,779	2,564,844

[1] Bureau of the Census, Monthly Statistics Superphosphate Industry, 16 per cent available phosphoric acid.
[2] Includes wet and dry bases and wet and dry mixed goods.
[3] Bureau of Foreign and Domestic Commerce. Figures on imports and exports in this table and in salient statistics table compiled by M. B. Price, of the Bureau of Mines.

souri, Montana, New York, Virginia, and Wisconsin.

Imports of pyrites for consumption in 1940 amounted to 407,004 long tons compared with 482,336 tons in 1939. Of the 1940 total Spain furnished 325,644 tons, Canada 81,157 tons, and Mexico 203 tons.

Exports of pyrites are not shown separately by the Bureau of Foreign and Domestic Commerce. No exports were reported by the producing companies in 1939 and 1940.

The average price of imported pyrites, as quoted by trade journals, was 12-13 cents per long ton unit of sulphur throughout the year.

Sweden Develops Phosphate Production from Apatite

Inasmuch as imports of phosphate rock into Sweden have been reduced considerably because of the blockade, it has been necessary to substitute domestic raw material. According to reports Sweden has found a good substitute in the apatite concentrate produced at the Malmberget flotation plant. The plant is owned by the semi-State Luossavaara-Kiirunavaara Aktb., Stockholm, Sweden, a subsidiary of Trafik Aktb. Grangesberg-Oxelosund, Sweden's largest iron-ore mining company. The plant, which is in full operation, is expected to yield about 20,000 to 25,000 metric tons of apatite concentrates per annum. The plant is being expanded to increase production.

Because the largest possible quantities of phosphate fertilizers, especially superphosphate, are needed to save Sweden's crop in 1941, the bulk of the apatite concentrate produced at the Malmberget plant at present is taken by the Swedish manufacturers of superphosphate, who convert the concentrates by the usual method.

In connection with further experimentation in the production of smelting phosphate, two smelting methods are used at present. The phosphate products to be manufactured by these two methods are expected to be perfected and in practical use in 1942. One is the so-called "stick" method invented by O. and B. Stälhane of Elektrövarmeinstitutet, Stockholm, and the other, in which the apatite concentrate is smelted in "troughs" or rotary kilns, was invented by S. C. Nordengren of Aktb. Förenade Superfosfatfabriker, Landakrona. Close cooperation has been established between the two companies, both State-subsidized for the experimental tests. Formerly Elektrövarmeinstitutet worked on a sintering method for the smelting of phosphate from the apatite concentrate but the method now has been abandoned as being uneconomic. The sintering method mentioned produces a phosphate similar to Thomas phosphate. Experiments have revealed that superphosphate combined with smelting phosphate—that is, superphosphate in the form of grains coated with smelting phosphate—has higher fertilizing qualities than superphosphate.

It is not believed that the domestically produced apatite concentrate can wholly replace imports of raw phosphate in normal times, because of price difference, etc. In war times, however, when the crude phosphate must be replaced by domestic material, cost of production is less important. With the current capacity of the Malberget flotation plant, imports of raw phosphate can be reduced by one-third and as soon as the plant is enlarged it is expected a further decrease in imports will be possible.

The Experimental Station of the High School of Agriculture at Experimental-fältet, Sweden, is testing the smelting of phosphates from apatite concentrate, but as these tests are not yet finished it is too early to report results.

POTASH CO. OF AMERICA ENLARGING PLANT

Potash Company of America announces plans to enlarge their plant capacity for producing muriate of potash. Work will start immediately, and it is thought the new unit will be in operation not earlier than some time in November, 1941. Until recently it was thought that the capacity for producing muriate of potash in the United States was ample to supply domestic requirements, but with increasing consumption in continental United States, its territories, Cuba and the Dominion of Canada, which American producers feel obligated to supply, and with the prospect that they may be called upon to ship muriate to Great Britain and Dominions other than Canada, it is felt that, to insure against a possible shortage, additional production capacity should be provided, as a contribution toward maintaining agricultural output at a level consistent with the emergency demands being made upon it.

This planned expansion on the part of Potash Company of America is another illustration of the ability of American industry to respond to the conditions imposed upon it as a result of the European conflict.

Liebig and the Microbiologist*

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SOCRATES often said of himself that he was only a "gad-fly" stinging minds to activity. To the microbiologists of the last century Justus von Liebig played much the same role. Present knowledge indicates that Liebig's concepts of microbiology were incorrect, but he forced his opponents to evolve ingenious techniques and to muster critical evidence in support of their theories. Harrassed by Liebig, the early bacteriologists were obliged to build a firm foundation for the structure of their science.

The prestige which Liebig had gained in the field of chemistry lent formidable weight to his postulates in other fields. In an era of less competent opposition his pronouncements might have stifled research, but to a man, such as Pasteur, criticism merely elicits further experimentation in a search for truth.

An analysis of Liebig's many contributions, which have been detailed to us this afternoon, reveals that they are all dependent upon his keen perception of and devotion to the science of chemistry. To him it seemed that all transformations should be reduced to chemical and physical law. With such a viewpoint he attempted to hurdle vitalistic steps in "natural" chemical changes and to refer them all to more directly reduced chemical reactions. It is not surprising then that Liebig was in constant disagreement with some of the foremost biologists of his day.

Let us trace the history of fermentation theories prior to the famous Liebig-Pasteur controversy. In 1776 Spallanzani had shown that organic materials in general could be permanently protected from undergoing fermentation and decomposition by being thoroughly boiled and subsequently shielded from all access to air. Gay-Lussac explained Spallanzani's result as due to the exclusion of atmospheric oxygen from the substances employed. He observed that a sample of grape-must, which had been preserved for a year, fermented after it had been transferred from one vessel to another, and had thus momentarily come in contact with air. He therefore argued that it was the presence of oxygen which was responsible for and essential to fermentation processes; this view was generally accepted until the vital theory of fermentation was again revived by Cagniard-Latour in 1837.

As early as 1675 Van Leeuwenhoeck had observed yeast cells in the deposit formed during fermentation. Cagniard-Latour showed that yeast cells were independent organisms multiplying by budding; he suggested that the life of these cells was intimately associated with the process of fermentation.

Shortly after the appearance of Cagniard-Latour's work, Schwann published his own extensive researches. The experiments were well conducted and now appear most convincing. Schwann showed that Gay-Lussac's theory of the dependence of fermentation processes upon the access of oxygen was untenable, for he proved that fermentable substances could be preserved unchanged even if they were brought in contact with air, as long as the latter had been first thoroughly heated. These results suggested to Schwann that the presence of organisms might play an important part in fermentative processes, and he therefore attempted to impede the alcoholic fermentation by addition of inhibitors. He observed that arsenic and a few other substances did interfere with fermentation, and also confirmed Cagniard-Latour's observation that the deposit produced during fermentation consisted of budding yeast cells. Schwann went further still and showed that the fermentation began with the appearance of these cells in the "must," and that it progressed with their multiplication, whereas with its cessation the growth of the yeast stopped also.

From these facts Schwann felt justified in restating the thesis of Cagniard-Latour; that there existed an undeniable connection between alcoholic fermentation and the growth of yeast cells. He suggested that the yeast cells utilized the sugar as their food material and that they separated out the unassimilated part in the form of alcohol. Turpin repeated and confirmed the researches of Schwann and interpreted his results essentially as had Schwann.

The vitalistic theory of fermentation, however, was not generally accepted by scientific authorities of the period. Helmholtz made his debut in the scientific world with a paper on fermentation and decay. He repeated

*Paper given at the Detroit meeting of the American Chemical Society, September, 1940.

Schwann's experiments and confirmed his observations that fermentation was suspended when the substances employed were boiled and brought in contact with heated air. But, reasoned Helmholtz, if the admission of ordinary air to these boiled substances induces fermentation and decay, then either germs must be held responsible or else these changes are due to the action of gaseous materials present in the atmosphere which are destroyed by heat. From his own experiments, Helmholtz inferred that, although alcoholic fermentation apparently was dependent to a certain extent upon vital processes, the putrefaction of nitrogenous substances was independent of germ life. He therefore came to the conclusion that the presence of microorganisms was a matter of only secondary importance, and that such microorganisms served merely to modify slightly the course of the fermentation process.

Liebig Attacks Vitalistic Theory

Liebig was contemptuous of the vitalistic approach. He said, "Those who attempt to explain the putrefaction of animal substances by the presence of animalcules argue much in the same way as a child who imagines he can explain the rapidity of the Rhine's flow by attributing it to the violent agitation caused by the numerous water-wheels of Mainz, in the neighborhood of Bingen. Can we legitimately regard plants and animals as the means whereby other organisms are destroyed, when their own constituent elements are condemned to undergo the same series of putrefactive phenomena as the creatures which preceded them? If the fungus is the agent of the oak's destruction, if the microscopic animalcule is the agent in the putrefaction of the elephant's carcass, I ask, in my turn, what is the agent which works the putrefaction of the fungus and the microscopic animalcule when life has been removed from these two organized bodies?" (2, p. 49)*

Again he asks, "In what respect does the explanation of fermentation appear to you any clearer when you have introduced into it a living organism, even if it is everywhere in it! But you see for yourself that they are not present in the putrefactions. Let us admit, if you wish, although it seems very extraordinary, that the meat and the sugar are destroyed by different methods. But the sugar can undergo diverse fermentations, very close to the alcoholic fermentation, and even frequently accompanying it: the lactic fermentations, the butyric, etc. Do you find in these fermentations anything resembling the yeast? Do they not behave exactly like the macerations of meat? Your explanation limps, and encounters obstacles at every step. For me, on the contrary, these transformations present a common character, namely, that of taking place, every one of them, in the presence of an organic substance in the process of decomposition. We start a lactic or butyric fermentation by means of old cheese, or putrid meat. As for the alcoholic fermentation Colin showed, in 1828, that this could be provoked by means of many organic nitrogenous substances, different from the yeast of beer, provided that they are in the process of decomposition. It is these dead substances which form the *ferment*. I do not forget the experiments of Thenard on the almost constant production of yeast in juices when in fermentation; I do not forget, furthermore, the conclusions of Cagniard-Latour and Schwann confirmed by Quevenne, Turpin, and Mitscherlich. But this yeast does not embarrass me, it enters into my system. If you admit that it lives, then you admit also that it dies. Now, it is in drying that it acts, as a result of the decomposition which it undergoes at this moment" (1, p. 64).

From these typical comments, it is evident that Liebig had little respect for the vitalistic explanation of fermentation. But what was his explanation of the phenomenon? On the whole it was as vague and ambiguous as vitalism at its worst. He was of the opinion that:

"Beer yeast, and, in general, all animal and vegetable matters in putrefaction impart to other bodies the state of decomposition in which they are themselves. The movement which, by the disturbed equilibrium, is impressed on their own elements, is communicated also to the elements of bodies in contact with them" (2, p. 35).

"There are forms of organic chemical decomposition in which a disturbance is produced in the mutual attraction of the elements of a compound, and they, in consequence, arrange themselves into one or into several new combinations, which are incapable of suffering further change under the same conditions" (3, p. 266).

Liebig willingly admitted the presence of yeast in alcoholic fermentations, but any action which it might have he attributed to its decomposition. The following statement purports to explain what part of the yeast is responsible for its activity:

"The insoluble part of the substance called ferment does not cause fermentation. For

*Numbers in parenthesis refer to literature listed at the end of the paper.

when the yeast from wine or beer is carefully washed with water, care being taken that it is always covered with this fluid, the residue does not produce fermentation. The soluble part of ferment likewise does not excite fermentation. An aqueous infusion of yeast may be mixed with a solution of sugar, and preserved in vessels from which the air is excluded, without either experiencing the slightest change. What then, we may ask, is the matter in ferment which excites fermentation, if neither the soluble nor insoluble parts possess the power? This question has been answered by Colin in the most satisfactory manner. He has shown that in reality it is the soluble part. But before it obtains this power, the decanted infusion must be allowed to cool in contact with the air, and to remain some time exposed to its action. When introduced into a solution of sugar in this state, it produces a brisk fermentation; but without previous exposure to the air, it manifests no such property. Yeast produces fermentation in consequence of the progressive decomposition which it suffers from the action of air and water" (3, p. 290).

This quotation suggests the need for at least momentary contact with oxygen for successful fermentation, a concept originally advanced by Gay-Lussac, whose data Liebig frequently cites. For example:

"Gay-Lussac showed by experiments that the juice of grapes expressed apart from air, under a bell jar full of mercury, did not enter into putrefaction, although it did so in the course of a few hours when air was admitted. It scarcely can be supposed, that the germs or fungi exist in chlorate of potash or black oxide of manganese, out of which the oxygen was obtained; and hence it is difficult to ascribe to a growing vegetation the causes of decomposition" (3, p. 329).

"The action of the oxygen in these processes of decomposition is very simple; it excites changes in the composition of the azotized matters dissolved in the juices; the mode of combination of the elements of those matters undergoes a disturbance and change in consequence of their contact with oxygen" (3, p. 303).

It is to be noted, however, that Liebig introduced a new factor into fermentation—the presence of a nitrogenous compound. He states:

"There is in the nature and constitution of the compounds of nitrogen a kind of tension of their component parts, and a strong disposition to yield to transformations, which effect spontaneously the transposition of their atoms from the instant that water or its elements are brought in contact with them. (3, p. 284). Every azotized constituent of the animal or vegetable organism runs spontaneously into putrefaction, when exposed to moisture and a high temperature. Azotized matters are, accordingly, the only causes of fermentation and putrefaction in vegetable substances" (3, p. 293).

These somewhat extensive and certainly typical quotations from Liebig should satisfactorily define his position. In brief he believed that fermentation was a process dependent upon the exposure to oxygen of material containing a nitrogenous compound. Exposure to oxygen started decomposition of the nitrogenous substance, which was then endowed with the ability to transmit its decomposition to other nitrogenous or non-nitrogenous organic compounds in contact with it. The ferment transmitted the motion of its molecular rearrangement to induce the same motion in adjacent substances.

Pasteur Enters the Arena

Fortunately, for our knowledge of fermentation, the vitalists had acquired a new champion. Pasteur, originally a chemist himself, was unimpressed by the prestige of the Master when the views of the latter conflicted with his own laboratory results. A veteran of many a scientific Donnybrook fair, Pasteur refused to be intimidated by the reputation of the foremost organic chemist of the day, but armed with the lethal weapons of precise laboratory technique and a pen dipped in cyanide he eagerly attacked his formidable antagonist.

Pasteur was influenced by his early studies in asymmetry. Observation on fermentation products, notably amyl alcohol, suggested to him that their asymmetry could be explained only on the basis of their vital production. He investigated the alcoholic and lactic acid fermentations and noted striking parallels: (1) both deposited a material in the bottom of his flasks which the microscope revealed to be a mass of living cells; (2) this material would transmit the fermentation in both cases; (3) and the two fermentations were sensitive to the same physical and chemical agents. These observations confirmed Pasteur in his vitalistic concept of fermentation.

Reversing the arguments of Liebig, he considered the possibility that ammonia did not arise from the protein substance of the fer-

(Continued on page 24)

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Principal Articles in This Issue

New Prices Issued by Potash Co. of America

On May 9th the Potash Company of America announced its schedule of prices for the year ending May 31, 1942, as follows:

Muriate of Potash, 60% K_2O minimum,
53½ cents per unit K_2O.

Muriate of Potash, 50% K_2O minimum,
55 cents per unit K_2O.

Manure Salts, Run-of-Mine Grade,
60 cents per unit K_2O.

The above prices are ex-vessel at any of 19 specified Atlantic and Gulf ports, from Searsport, Me., to Houston, Tex.

The above list prices are subject to the following discounts:

On orders placed by June 30, 1941, for delivery during June, 1941, or in substantially equal monthly quantities from July 1, 1941 to January 31, 1942, 8%.

Upon acceptance of delivery of entire tonnage on order by January 31, 1942, an additional allowance of 4%.

On orders placed after June 30, 1941 for delivery at buyer's plant prior to and including May 31, 1942, list prices will apply.

At the buyer's option, the above grades of muriate of potash may be purchased f.o.b. Carlsbad, New Mexico, at a reduction of 11.2 cents per unit K_2O from the prevailing ex-vessel price, subject to the same seasonal discounts as above. This makes the net price about $7.00 per ton less than the ex-vessel price on high-grade muriate.

The prices quoted are for shipment in bulk, either by steamship or in minimum carloads of 40 tons each.

The prices quoted are guaranteed against lower competitive prices on deliveries to and including May 31, 1942. In case lower prices are subsequently quoted by the company, these lower prices will apply to all tonnage delivered and still in the buyer's hands. This guarantee does not cover reductions not general in nature, nor will it apply to any change in terms or conditions imposed by Federal Authority.

Deliveries of muriate can be cancelled by the company if the material is needed in connection with national defense. In that event the buyer may take manure salts in place of the muriate, with adjustment of delivered cost to the muriate basis.

During the past year the list prices of potash were: muriate, 50% or 60%, 53½ cents per unit K_2O; manure salts, run-of-mine, 60 cents per unit K_2O.

N. F. A. CONVENTION

The Seventeenth Annual Convention of The National Fertilizer Association will be held at White Sulphur Springs, West Virginia, on June 9, 10 and 11, 1941. The sessions will be held, as usual, at the Greenbrier. Further announcement will be made as to hotel rates, railroad fares, etc.

Sulphur in 1940

Production of crude sulphur in the United States in 1940 increased to 2,732,088 long tons, or 31 per cent, compared with the output in 1939 of 2,090,979 tons, according to the Bureau of Mines, United States Department of the Interior. Record shipments of 2,558,742 long tons, valued at about $40,900,000 were made in 1940, compared with 2,233,817 tons, valued at about $35,500,000 in 1939. Stocks of sulphur at the mines rose from 4,000,000 long tons at the close of 1939 to 4,200,000 tons on December 31, 1940. Production of sulphur was reported from California, Louisiana, Texas, and Utah.

Texas increased its production from 1,665,400 long tons in 1939 to 2,212,839 tons in 1940, or 33 per cent. Shipments increased to 2,008,968 tons in 1940, a gain of 13 per cent over the 1,784,952 tons shipped in 1939. The properties that contributed to the Texas production in 1940 were those of the Duval Texas Sulphur Company at Orchard Dome, Orchard, Fort Bend County, and at Boling Dome, Boling, Wharton County; Freeport Sulphur Company at Hoskins Mound, Freeport, Brazoria County; Jefferson Lake Sulphur Company, Inc., at Clemens Dome, Clemens, Brazoria County; and the Texas Gulf Sulphur Company at Boling Dome, Newgulf, Wharton County.

Louisiana produced 512,935 long tons of sulphur in 1940, compared with 422,600 tons in 1939, a gain of 21 per cent. Shipments amounted to 543,004 tons, a gain of 22 per cent over the 446,242 tons shipped in 1939. As in 1939, the Freeport Sulphur Company was the only producer in Louisiana.

Production of sulphur in California and Utah in 1940 was 6,314 long tons, compared with 2,979 tons in 1939. The Bureau of Mines is not at liberty to publish figures for California and Utah separately.

The average quoted price of crude sulphur as reported by trade journals was $16 per ton f.o.b. mines, throughout the year.

According to the Bureau of Foreign and Domestic Commerce, imports of sulphur ore (all from Chile) in 1940 were 743 pounds valued at $5, while imports of sulphur in any form were 27,845 long tons valued at $473,052.

Exports of crude sulphur in 1940 totaled 746,468 long tons, compared with 627,819 tons in 1939, an increase of 19 per cent. Important quantities of American sulphur were exported to the following countries in 1940: United Kingdom received 245,469 tons in 1940 compared with 112,810 tons in 1939; Canada, 197,746 tons compared with 142,437 tons; Australia, 78,766 tons compared with 109,341 tons; New Zealand, 64,776 tons compared with 49,753 tons; British India, 32,061 tons compared with 21,880 tons; France, 29,498 tons compared with 39,811 tons; and Union of South Africa, 29,460 tons compared with 19,911 tons. Exports of crushed, ground, refined, sublimed and flowers of sulphur in 1940 were 44,229,114 pounds, a decrease of 21 per cent below the 56,012,035 pounds shipped abroad during 1939. The principal importing countries were British India with 10,196,192 pounds; Canada, 5,983,432 pounds; Brazil, 5,334,804 pounds; Turkey, 4,696,245 pounds; United Kingdom, 3,986,698 pounds; Union of South Africa, 2,580,447 pounds; and Mexico, 2,034,873 pounds. No other country received as much as a million pounds.

NEW BOOKLET ON FERTILIZERS

The Plant Food Institute of North Carolina and Virginia, Inc., of Raleigh, N. C., an organization formed by 15 fertilizer manufacturers doing business in those states, to publish scientific and practical information on all kinds of plant foods, their application to crops, etc., have issued a 64-page booklet entitled "The Story of Fertilizer."

This booklet has been prepared to fill a definite need for concise and reliable information about the development of the fertilizer industry, and the manufacture and use of fertilizers. Among the subjects treated are: Plant Food Requirements for Farm Crops; How Plant Food Deficiencies Are Determined; Fertilizer Recommendations; Approved Methods of Fertilizer Application; How Fertilizers Are Made; Economy of High Analysis Fertilizers. This booklet should be of great help in promoting the intelligent use of fertilizers in these two states.

April Tag Sales

Fertilizer sales in April in 17 States, as measured by the sale of tax tags, amounted to 1,461,189 tons. This represented increases of 24 per cent and 14 per cent over April, 1940, and April, 1939, respectively.

Aggregate sales in the South were 24 per cent larger than a year earlier, with all of the 12 States reporting significant increases. Sales in most States in the region were also larger than two years ago.

Illinois was the only State in the Midwest to report a decline from April, 1940, but this was much more than offset by increases in the other four States. For the region as a whole the gain amounted to 22 per cent.

March sales had been considerably smaller than last year but this was more than made up by the rise in April. January-April sales in the 17 reporting States were 9 per cent larger than in the same period of each of the last two years.

It is significant that every one of the 17 States reported larger sales for the four-month period. It is seldom that such a general and widespread improvement takes place. The improvement represents the combined effect of higher farm purchasing power, low fertilizer prices, and educational activities of the industry and government agencies.

In 1940, tag sales in the January-April period represented 51 per cent of total sales in the United States for the entire year. It is apparent that fertilizer consumption this year may be at a new all-time peak.

FERTILIZER TAX TAG SALES

	April				January-April			
	1941				1941			
State	Per Cent of 1940	Tons	1940 Tons	1939 Tons	Per Cent of 1940	Tons	1940 Tons	1939 Tons
Virginia	110	88,746	80,608	90,905	105	260,219	248,391	270,098
N. Carolina	107	350,187	326,244	371,434	103	914,875	884,556	1,005,967
S. Carolina	117	169,509	145,278	173,192	103	604,763	589,658	584,871
Georgia	118	209,988	178,641	160,368	110	723,372	657,524	615,153
Florida	126	47,986	38,037	20,911	118	251,891	214,044	188,900
Alabama	132	255,100	193,050	195,800	104	526,950	506,000	497,400
Mississippi	201	90,785	45,257	117,775	122	294,037	241,270	257,375
Tennessee	128	67,645	52,772	44,493	116	107,663	92,454	91,954
Arkansas	159	31,400	19,750	12,000	121	104,200	85,950	62,900
Louisiana	165	41,300	25,100	27,751	110	140,230	127,411	120,801
Texas	182	37,295	20,540	17,640	110	107,092	97,556	76,674
Oklahoma	701	841	120	10	163	8,637	5,293	6,028
Total South	124	1,390,782	1,125,397	1,232,279	108	4,043,929	3,750,107	3,778,121
Indiana	110	24,622	22,357	17,313	118	160,309	135,376	111,608
Illinois	66	9,299	14,129	3,862	114	30,328	26,636	19,888
Kentucky	164	31,038	18,983	20,815	130	76,787	59,094	61,823
Missouri	268	5,048	1,882	2,062	138	35,531	25,770	20,827
Kansas	140	400	285	5	205	5,433	2,653	1,320
Total Midwest	122	70,407	57,636	44,057	124	308,388	249,529	215,466
Grand Total	124	1,461,189	1,183,033	1,276,336	109	4,352,317	3,999,636	3,993,587

FERTILIZER MATERIALS MARKET

NEW YORK

Shipments Continue in Good Volume but End of Season is in Sight. Fill-in Orders for Potash Reported. Fertilizer Manufacturers Figuring on Next Year's Requirements

Exclusive Correspondence to "The American Fertilizer."

NEW YORK, May 6, 1941.

Mixed goods continued to move in good volume throughout last week in the East, but we understand that this business is now slackening somewhat.

Muriate of potash is a bit scarce and some of the larger buyers have found it necessary to order rush shipments at full schedule. However, as a whole, the domestic manufacturers have been fairly well taken care of on their potash in spite of the continued strike at one of the larger domestic potash plants. Buyers are starting to figure on their next year's requirements of potash, even though no new prices have as yet been released.

Nitrate of Soda

Price unchanged with fair movement. Price $27.00, bulk basis.

Superphosphate

No change in price and no unusual demand.

Potash

For spot delivery, full schedule of 53½ cents is being maintained.

Nitrogenous Material

With the booking of considerable quantities, the demand is now lighter but the market is firm.

Bone Meal

Nominal quotation on South American raw bone meal continues at $36.00 subject to freight being obtainable.

Dried Blood

The New York market is quiet and relatively unchanged to slightly lower. Offerings are comparatively light as sellers for the most part are fairly well sold up, but at the same time demand is not too active. Last trade was at $3.40 ($4.13½ per unit N). Some South American material was lately offered at $3.20 ($3.89 per unit N), c.i.f. for shipment. Spot stocks of imported material, where existent, are firmly held at $3.25 ($3.95 per unit N) and $3.50 ($4.25½ per unit N), depending upon location and individual views of sellers.

Tankage

This market is more or less quiet at the moment. Sellers are offering 9/10 per cent unground material at $3.50 ($4.25½ per unit N) and 10 cents, but there is little, if any, buying interest.

Fish Scrap

Last business was done at $4.35 ($5.29 per unit N) and 10 cents on customary "if and when made" conditions. Producers are not particularly aggressive toward further sales but there is still some further buying interest on the market at this level.

BALTIMORE

Warm Weather Advances Season and Shipments Tapering Off. Rising Ocean Freights Affect Prices of Some Materials.

Exclusive Correspondence to "The American Fertilizer."

BALTIMORE, May 6, 1941.

The peak of the spring shipping season is about over as unseasonably warm and dry weather advanced the season about two weeks, and all manufacturers during the past month have been running to capacity. From now on, it is anticipated that the tonnage will taper off, and if the weather remains warm and dry, the season will probably wind up earlier than usual.

Ammoniates.—The market on tankage for feeding purposes is sharply higher, being equivalent to about $3.90 per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. basis Baltimore. There are offerings of South American ground dried blood on the market at around $3.80 per unit of nitrogen.

Nitrogenous Material.—There are no offerings of the foreign product on the market, and the market on the domestic continues nominally around $2.75 per unit of nitrogen, f.o.b. Baltimore.

Sulphate of Ammonia.—There has been practically no resale demand for fertilizer purposes, although it is reported that there have been offerings on the market ranging from $32.00 to $35.00 per ton, without any business of consequence being booked on this basis. It is anticipated that the market for another season will be higher on account of the tonnage which will be required under the National Defense Program.

Nitrate of Soda.—Withdrawals continue quite heavy, as is usual at this time of the year. There is no change in the market, which remains at $29.40 per ton of 2,000 lb., in 100-lb. bags, with usual differential for bulk and 200-lb. bags, f.o.b. port warehouse, with no change anticipated until after June 30th.

Fish Scrap.—It is reported that producers' views are about $5.40 per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. fish factories, for shipment "if and when made," and subject to catch, but very little interest is being shown on this basis on account of the comparatively higher cost, as compared with other feeding materials.

Superphosphate.—Due to curtailment of vessels available to carry phosphate rock, with consequent materially higher freight rates, an advance in price of superphosphate is looked for, although the present market remains unchanged at $8.00 per ton of 2,000 lb., basis 16 per cent for run-of-pile, and $8.50 for flat 16 per cent grade, no charge for excess, both in bulk, f.o.b. producers' work, Baltimore. Sellers, however, are not booking forward deliveries on this basis.

Bone Meal.—With the recession of foreign arrivals and difficulty in securing freights on the South American product, the market here is ruling considerably higher, and 3 and 50 per cent steamed bone is quoted around $37.00 per ton, while 4½ and 47 per cent raw bone meal ranges from $32.00 to $35.00 per ton, f.o.b. Baltimore.

Potash.—There has been practically no resale demand as domestic manufacturers have been able to supply manufacturers legitimate requirements, but as ocean freights enter into the delivered price even on the domestic goods, a higher market is looked for when producers are ready to book for another year's business.

Bags.—The market on burlap continues to advance, and is firm at the higher prices. Some of the bag manufacturers are short of spot burlap, with the result that the present market on plain, new 10 oz. basis 40 cut 54 in. is about $202.00 per thousand, f.o.b. Baltimore. On account of the present high market on burlap bags, many of the manufacturers are using paper bags, and if burlap should continue high for another season, even larger quantities of paper will be used than during the present season.

CHARLESTON

Nitrate of Soda Moving in Heavier Volume. Superphosphate Scarce with Higher Prices Likely for Next Season.

Exclusive Correspondence to "The American Fertilizer."

CHARLESTON, May 5, 1941.

The movement of mixed fertilizers has now slowed up and nitrate of soda has begun to move a little, although the heavy movement will not develop for a week or ten days. Sulphate of ammonia and potash continue scarce.

Nitrogenous.—Domestic can be obtained around $1.75 to $1.80 ($2.12½ to $2.19½ per unit N), f.o.b. Midwestern points.

Blood.—Around $3.50 ($4.25½ per unit N), bulk Chicago; South American, around $3.15 to $3.20 ($3.83 to $3.89 per unit N), c.i.f. Atlantic ports where freight can be obtained, but this is extremely difficult.

Fish Meal.—Spot menhaden meal, $61.50 to $62.00 per ton, f.o.b. Baltimore.

Cottonseed Meal.—Around $29.00 for 8 per cent at Atlanta and $24.50 for 8 per cent at Memphis.

Superphosphate.—In spite of the fact that producers of this material in the southeast have been running their mills at a very heavy rate, superphosphate continues very strong and scarce. Indications point to a higher price for the coming season on account of higher rock and the possibility of a higher price on sulphur.

ATLANTA

Settlement of Coal Strike Eases Sulphate of Ammonia Situation. Higher Prices Expected on Almost All Materials for Next Season.

Exclusive Correspondence to "The American Fertilizer."

ATLANTA, May 6, 1941.

Settlement of the coal strike has assured a continuous supply of sulphate of ammonia, whereas for a while it appeared that production would be seriously curtailed, had the strike continued any longer.

In this connection, it is entirely possible that the supply of mineral nitrogen for another year may be curtailed. Even now, the Government is requisitioning certain sources of supply and high freight rates are having their effect on natural nitrates that have to be imported. All of these factors may be reflected in somewhat higher prices for another season. In fact, forward looking buyers are insuring their supplies of organic nitrogen while they are to be had at current levels which, on the average, are quite favorable.

As we are brought to rely more and more on our domestic sources of supply, it is quite natural that we should see somewhat firmer markets in the future because our domestic sources have never been able to fully supply the demand for certain materials that find their largest outlet in the fertilizer and feed trade.

While price fixing on the part of the Government may be invoked to limit any radical price advances, still it would appear that we are to be confronted with a firmer trend in practically all of the major markets in which fertilizer manufacturers are interested. Current quotations are as follows:

South American Blood.—$3.25 ($3.95 per unit N), c.i.f.

Tankage.—$3.35 ($4.07 per unit N) and 10 cents, c.i.f.

Domestic Nitrogenous Tankage. — $1.75 ($2.12½ per unit N), f.o.b. western producing points.

Fish Materials.—Scarce, with practically nothing offered.

Sulphate of Ammonia.—Resales at $31.00 to $32.00, basis f.o.b. the port.

Nitrate of Soda.—Unchanged.

Cottonseed Meal.—Prime 8 per cent meal, $24.00; southeastern mills, $25.50.

Peanut Meal. — 8.75 per cent ammonia, $22.00 to $23.00, average mill points.

PHILADELPHIA

Demand Slackens and Prices Easier. Restrictions on Sulphate of Ammonia Exports Cause Drop in Resale Prices.

Exclusive Correspondence to "The American Fertilizer."

PHILADELPHIA, May 7, 1941.

During the past interval there has been a noticeable decrease in inquiry for raw materials and prices in most lines have eased off slightly. This condition will probably be corrected with a change in the weather.

Sulphate of Ammonia.—With export licenses practically impossible to obtain, the market has eased off and resale lots are being offered at considerably under recent prevailing prices.

Nitrate of Soda.—Withdrawals have been light.

Blood and Tankage.—Blood holds firm, but tankage for both fertilizer and feeding purposes has eased off slightly.

Bone Meals.—Remain scarce and prices hold firm.

Potash Salts.—A temporary shortage in this section appears to have been quickly remedied.

Low-Grade Ammoniates.—Are in good demand and prices are firm and advancing.

Fish Meals.—The heavy demand of a few weeks ago has dropped off but prices remain unchanged.

TENNESSEE PHOSPHATE

Rock Producers Behind in Shipments in Spite of Record Production. Construction Work Proceeding Rapidly.

Exclusive Correspondence to "The American Fertilizer."

COLUMBIA, TENN., May 5, 1941.

The long predicted excess of demand over supply has come about, at least temporarily, with the largest first four months' shipments of phosphate rock into all consuming channels that has taken place in the life of the Tennessee phosphate mining industry. All producers are from ten to thirty carloads behind in their shipping.

Of course, this excessive demand will rapidly decline as farmers get into their regular work, following spring planting time, and turn their attention away from fertilizer applications, giving producers a chance to again accumulate stocks against the next heavy shipping season during August to October.

Weather conditions have been marvelous for outside work and all the construction work on the TVA plants. Hoover & Mason changes, and other similar work is proceeding with the utmost rapidity, hampered only by delayed deliveries of steel and some other building materials.

The AAA in Illinois decided to establish in eleven counties the same plan for grants-of-aid purchase of rock phosphate as is under way in all sections of the U. S. for superphosphate and TVA products, but instead of providing in the specifications for high grade phosphate

rock that has been sold in Illinois for forty years or more, they adopted the low grade waste product specification, which is worth only about 75 per cent as much as the high grade.

Unfortunately the local people connected with the AAA are representing to farmers, through press articles and otherwise, that it is the same product that consumers get from ordinary sellers at much higher prices, while as a matter of fact the AAA material at their prices is still higher per unit of effective phosphate than the prices at which the high grade product is sold.

CHICAGO

Season Ending but Interest in Future Purchases of Fertilizer Organics Continues. Feed Material Demand Lighter.

Exclusive Correspondence to "The American Fertilizer."

CHICAGO, May 5, 1941.

With the passing of April, all hope of "fill in" business for this season ended, but the great buying interest recently shown for futures prevented any decline in the market. Moreover, sellers maintain that their carry-over is exceedingly small and this seems correct, judging by their present firm position.

The feed market is showing an easier tone as consuming demand has slackened and although production of materials is somewhat below normal, mixers have reduced their buying views.

Nominal prices are as follows: High grade ground fertilizer tankage, $2.20 to $2.25 ($2.67½ to $2.73½ per unit N) and 10 cents; standard grades, crushed feeding tankage, $3.50 to $3.65 ($4.25½ to $4.43½ per unit N) and 10 cents; blood, $3.40 to $3.50 ($4.13½ to $4.25½ per unit N); dry rendered tankage, 75 to 80 cents per unit of protein, Chicago basis.

"HUNGER SIGNS IN CROPS"

After five years' preparatory work, The American Society of Agronomy and The National Fertilizer Association have completed publication of the long-awaited book "Hunger Signs in Crops."

Modern science has recently found that many human ailments once believed to be due to bacteria or which were entirely unexplained are really due to hidden hunger—failure to supply all of the elements needed by the body. Now scientists have also found that hidden hunger may affect plants as well as human beings—that many so-called plant diseases are merely "hunger signs" or symptoms of plant-food deficiencies. Farmers gave them names such as "fired" corn, "sand drown" in tobacco, "die-back" in citrus, "drought spot" in apples, "heart rot" in beets, "rust" in cotton, and many others.

"Hunger Signs in Crops" gives in practical form much of the present knowledge of these symptoms that develop in growing crops when they lack needed elements.

This book represents five years' work by a group of scientists interested in giving to the agricultural public valuable and up-to-date information on plant feeding. Its nine chapters which deal with all of the major and with many of the minor crops, were written by a group of

See Page 4

fourteen able scientists, all of whom have had many years of experience in the field covered.

The Committee on Fertilizers of The American Society of Agronomy supervised the assignment of the chapters to competent authors, all of whom worked without compensation. The National Fertilizer Association assumed the responsibility of finding a way to publish the book and make it available at a low price. Its popularity is indicated by the fact that over 6,000 copies were purchased in advance of publication. Without this large advance sale the cost of the book would have been at least doubled.

The volume is priced at $2.50 and contains 340 pages, with 79 color plates and 95 halftone illustrations. It will be found to be an essential part of every fertilizer man's library. Orders may be placed directly with the printer, Judd & Detweiler, Inc., Florida Ave. & Eckington Place, Washington, D. C.

LIEBIG AND THE MICROBIOLOGIST

(Continued from page 11)

ment but that protein was produced from ammonia. For testing this hypothesis, he devised a crucial experiment. The problem was to grow yeast in a liquid deprived of all organic nitrogenous matter; a medium containing only pure sugar, mineral salts with ammonia as a source of nitrogen. Pasteur reasoned that if this medium, devoid of the organic nitrogenous matter which Liebig declared to be necessary, underwent fermentation, and if, at the same time the yeast multiplied and developed entirely at the expense of such simple constituent as sugar, ammonia and mineral salts, one could scarcely deny a correlation between fermentation and the development of life. In such a case Liebig's idea was dead rather than the ferment. Pasteur's task was not easy, but he finally succeeded in obtaining reasonably good growth in his synthetic medium.

In the face of such experiments, Liebig was hard pressed to preserve his theory of fermentation. Contrasting his statements following Pasteur's work, with those previously cited suggests that Liebig was attempting to reconcile the two theories without giving too much ground. We quote:

"Observations that flesh and other animal bodies may be kept for several weeks without putrefying, if placed in a vessel containing air previously heated to redness, have gone far to support the opinion that the process of putrefaction is effected by the growth of organic beings; but all such experiments are of very subordinate value in support of these conclusions. It is possible, and indeed probable that fungi may have the power of growing in fermenting and putrefying substances, in as far as the products arising from the putrefaction are adapted for their nourishment. The putrefaction cannot be viewed as the act of the formation of organic beings, but as the act of the passage of their elements into inorganic compounds" (3, p. 330).

Liebig moreover concedes the following activity to microorganisms in the fermentation process:

"As in the case with all excrements, these (excrements of the infusoria) must possess, in an eminent degree, the property of passing into decay or putrefaction; and this condition must at all events be induced by contact with the original putrefying body. Hence, the increase in numbers of the infusoria must induce and accelerate the process of putrefaction in the putrifying body itself" (3, p. 331).

Forsaking verbal artillery alone, Liebig at this juncture resorted to experimentation. His attempt to grow yeast on a synthetic medium was unsuccessful, and he immediately called Pasteur to task on this point. In the light of our present knowledge it is not difficult to reconstruct the situation and explain the discrepancy in the results of these two competent men. Yeast cannot be grown successfully in a synthetic medium if a small inoculum is employed unless the medium is fortified with traces of organic growth factors. However, if a heavy inoculum is used, sufficient growth factors are carried over to initiate growth in the new medium, and the actively growing cultures can then synthesize most of their requirements. It would not surprise us if the "vitalist" Pasteur had used a generous inoculum in seeding his synthetic medium, nor would we be taken aback to find that Liebig was a bit niggardly in his transfer technique. Thus each was correct in his experiments, and

each obtained the results necessary to confirm his ideas.

Liebig presented his data in an extensive communication to the Munich Academy in 1869. By this time Pasteur had well established the vitalistic theory of fermentation, and Liebig's paper was largely a strategic retreat in which he suggested that there was little difference in the two interpretations of fermentation processes. After a more or less successful rearguard action, however, Liebig countered with his challenge to Pasteur's observation that yeast could be grown on a synthetic medium. He followed this thrust with a denial that the beechwood shavings of *Riemerschmieds,* Munich vinegar factory, contained *Mycoderma aceti,* as would be expected from Pasteur's contention that acetic acid was a metabolic product of this organism.

Liebig Sues for Armistice

Liebig then sued for an armistice, making a concession, on condition that Pasteur should do likewise. He extended the olive branch in these words,

"I grant you, that this is a vital phenomenon taking place in a living organism, provided you grant me that it is of a chemical order. If you do not make this concession, I shall always have the right to say that you have not looked into the question far enough, that you have been arrested before a closed door which I am trying to open" (1, p. 130).

In his reply to Liebig, Pasteur somewhat belligerently offered to submit the controversies to a commission from the academies. He volunteered to prepare several kilograms of yeast from a synthetic medium and to demonstrate *Mycoderma aceti* on the beechwood shavings of Herr Riemerschmied's vinegar factory. The aging Liebig did not accept the challenge but instead wrote to Duclaux in the manner of a tired and not too happy old warrior:

"I have often thought in my long practical career and at my age (69) years), how much pains and how many researches are necessary to probe to the depths a rather complicated phenomenon. The greatest difficulty comes from the fact that we are too much accustomed to attribute to a single cause that which is the product of several, and the majority of our controversies come from that. I would be much pained if M. Pasteur took in a disparaging sense the observations in my last work on fermentation. He appears to have forgotten that I have only attempted to support with facts a theory which I evolved more than 30 years ago, and which he had attacked. I was, I believe, in the right defending it. There are very few men whom I esteem more than M. Pasteur, and he may be assured that I would not dream of attacking his reputation, which is so great and has been so justly acquired. I have assigned a chemical cause to a chemical phenomenon, and that is all I have attempted to do" (1, p. 132).

In retrospect it is evident that the struggle between these two scientific giants, Liebig and Pasteur, did much to clarify the problem of fermentation. Although the microbiologist is loath to give Liebig much credit in his controversy with the "Father of Bacteriology," he must admit that fundamentally both men were right. As noted by Duclaux (1), the term "vital phenomenon" which Pasteur resolved upon, was in no sense more exact than Liebig's phrase "molecular disintegration." Eventually all phases of nutrition within the cell are reduced necessarily to chemical phenomena. Present knowledge of biological processes provides us with a wider base which readily embraces the ideas of both Liebig and Pasteur. We no longer believe that life *per se* is necessary for biochemical changes but that it is required primarily for production of the enzymatic agents which induce the stepwise chemical reactions called fermentations.

Even though the microbiologist is often uncharitable to Justus von Liebig, he will not deny him the title of "the supreme gad-fly of the craft."

References

1. Duclaux, E. (1896) Pasteur: The History of a Mind Translation, Smith, E. F., and Hedges, F. (1920); Saunders, Philadelphia.

2. Frankland, P., and Mrs. P. Frankland (1898) Pasteur; MacMillan, New York.

3. Liebig (1840), Chemistry in its Applications to Agriculture and Physiology—Translation, Playfair, L., and Gregory, W. (1872); Wiley, New York.

BUYERS' GUIDE

A CLASSIFIED INDEX TO ALL THE ADVERTISERS IN "THE AMERICAN FERTILIZER"

This list contains representative concerns in the Commercial Fertilizer Industry, including fertilizer manufacturers, machinery and equipment manufacturers, dealers in and manufacturers of commercial fertilizer materials and supplies, brokers, chemists, etc. For Alphabetical List of Advertisers, see page 33.

ACID BRICK
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

ACID EGGS
Chemical Construction Corp., New York City.

ACIDULATING UNITS
Chemical Construction Corp., New York City.
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Hydrocarbon Products Co., New York City.

AMMONIA LIQUOR
Barrett Company, The, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Hydrocarbon Products Co., New York City.

AMMONIA OXIDATION UNITS
Chemical Construction Corp., New York City.

AMMONIATING EQUIPMENT
Sackett & Sons Co., The A. J., Baltimore, Md.

AMMONIUM NITRATE SOLUTIONS
Barrett Company, The, New York City

AUTOMATIC ELEVATOR TAKEUPS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BABBITT
Sackett & Sons Co., The A. J., Baltimore, Md.

BAGS AND BAGGING—Manufacturers
Bagpak, Inc., New York City.
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Cotton
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Paper
Bagpak, Inc., New York City.
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS (Waterproof)—Manufacturers
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Dealers and Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BAGGING MACHINES—For Filling Sacks
Atlanta Utility Works, East Point, Ga.
Bagpak, Inc., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

BAG PILERS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.

BEARINGS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BELT LACING
Sackett & Sons Co., The A. J., Baltimore, Md.

BELTING—Chain
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

BELTING—Leather, Rubber, Canvas
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

BOILERS—Steam
Atlanta Utility Works, East Point, Ga.

BONE BLACK
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Huber & Company, New York City.

BONE PRODUCTS
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

BORAX AND BORIC ACID
American Potash and Chem. Corp., New York City.
Pacific Coast Borax Co., New York City.

BROKERS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Keim, Samuel L., Philadelphia, Pa.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BUCKETS—Elevator
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CABLEWAYS
Hayward Company, The, New York City.

CARBONATE OF AMMONIA
American Agricultural Chemical Co., New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CARS—For Moving Materials
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.

CASTINGS—Iron and Steel
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

CHAIN DRIVES—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAINS AND SPROCKETS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAMBERS—Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CHEMICAL APPARATUS
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

CHEMICALS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CHEMICALS—Continued
Huber & Company, New York City.
Phosphate Mining Co., The, New York City.
Wellmann, William E., Baltimore, Md.

CHEMICAL PLANT CONSTRUCTION
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHEMISTS AND ASSAYERS
Gascoyne & Co., Baltimore, Md.
Shuey & Company, Inc., Savannah, Ga.
Stillwell & Gladding, New York City.
Wiley & Company, Baltimore, Md.

CLUTCHES
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CONCENTRATORS—Sulphuric Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CONDITIONERS AND FILLERS
American Limestone Co., Knoxville, Tenn.
Phosphate Mining Co., The, New York City.

CONTACT ACID PLANTS
Chemical Construction Corp., New York City.

COPPER SULPHATE
Tennessee Corporation, Atlanta, Ga.

COTTONSEED PRODUCTS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CYANAMID
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
Chemical Construction Corp., New York City.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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DISINTEGRATORS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DRYERS—Direct Heat
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
Link-Belt Company, Philadelphia, Chicago.

DUMP CARS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DUST COLLECTING SYSTEMS
Sackett & Sons Co., The A. J., Baltimore, Md.

ELECTRIC MOTORS AND APPLIANCES
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

ELEVATORS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ELEVATORS AND CONVEYORS—Portable
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

ENGINEERS—Chemical and Industrial
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

EXCAVATORS AND DREDGES—Drag Line and Cableway
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.

FERTILIZER MANUFACTURERS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Farmers Fertilizer Co., Columbus, Ohio
International Agricultural Corp., New York City.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

FISH SCRAP AND OIL
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

FOUNDERS AND MACHINISTS
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GARBAGE TANKAGE
Wellmann, William E., Baltimore, Md.

GEARS—Machine Moulded and Cut
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GEARS—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Duriron Co., Inc., The, Dayton, Ohio.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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MACHINERY—Grinding and Pulverizing
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Power Transmission
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Pumping
Atlanta Utility Works, East Point, Ga.
Duriron Co., Inc., The, Dayton, Ohio.

MACHINERY—Tankage and Fish Scrap
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MAGNETS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
McIver & Son, Alex. M., Charleston, S. C.
Tennessee Corporation, Atlanta, Ga.

MIXERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Agricultural Corp., New York City.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
Chemical Construction Corp., New York City.

NITROGEN SOLUTIONS
Barrett Company, The, New York City

NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., Wilmington, Del.
Huber & Company, New York City.
International Agricultural Corp., New York City.
McIver & Son, Alex. M., Charleston, S. C.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
Monarch Mfg. Works, Philadelphia, Pa.

PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

PANS AND POTS
Stedman's Foundry and Mach. Works, Aurora, Ind.

PHOSPHATE MINING PLANTS
Chemical Construction Corp., New York City.

PHOSPHATE ROCK
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Charleston Mining Co., Inc., Richmond, Va.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Jett, Joseph C., Norfolk, Va.
Phosphate Mining Co., The, New York City.
Ruhm, H. D., Mount Pleasant, Tenn.
Schmaltz, Jos. H., Chicago, Ill.
Southern Phosphate Corp., Baltimore, Md.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
Duriron Co., Inc., The, Dayton, Ohio.

PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers and Importers
American Potash and Chem. Corp., New York City.
Potash Co. of America, Baltimore, Md.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., New York City.
Jett, Joseph C., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

QUARTZ
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

RINGS—Sulphuric Acid Tower
Chemical Construction Corp., New York City.

ROUGH AMMONIATES
Bradley & Baker, New York City.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

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SCALES—Including Automatic Bagging
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SCRAPERS—Drag
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

SCREENS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SEPARATORS—Air
Sackett & Sons Co., The A. J., Baltimore, Md.

SEPARATORS—Including Vibrating
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

SEPARATORS—Magnetic
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SHAFTING
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SHOVELS—Power
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

SPRAYS—Acid Chambers
Monarch Mfg. Works, Inc., Philadelphia, Pa.

SPROCKET WHEELS (See Chains and Sprockets)

STACKS
Sackett & Sons Co., The A. J., Baltimore, Md.

SULPHATE OF AMMONIA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Hydrocarbon Products Co., New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L.; Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

SULPHUR
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Freeport Sulphur Co., New York City.
Texas Gulf Sulphur Co., New York City.

SULPHURIC ACID
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.

SULPHURIC ACID—Continued
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.
Wellmann, William E., Baltimore, Md.

SUPERPHOSPHATE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.
Wellmann, William E., Baltimore, Md.

SUPERPHOSPHATE—Concentrated
Armour Fertilizer Works, Atlanta, Ga.
International Agricultural Corp., New York City.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

SYPHONS—For Acid
Monarch Mfg. Works, Inc., Philadelphia, Pa.

TALLOW AND GREASE
American Agricultural Chemical Co., New York City.

TANKAGE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
International Agricultural Corp., New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Smith-Rowland, Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

TANKAGE—Garbage
Huber & Company, New York City.

TANKS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons, Co., The A. J., Baltimore, Md.

TILE—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

TOWERS—Acid and Absorption
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

UNLOADERS—Car and Boat
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

UREA
DuPont de Nemours & Co., E. I., Wilmington, Del.

UREA-AMMONIA LIQUOR
DuPont de Nemours & Co., E. I., Wilmington, Del.

VALVES—Acid-Resisting
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

WHEELBARROW (See Carts)

ZINC SULPHATE
Tennessee Corporation, Atlanta, Ga.

ALPHABETICAL LIST OF ADVERTISERS

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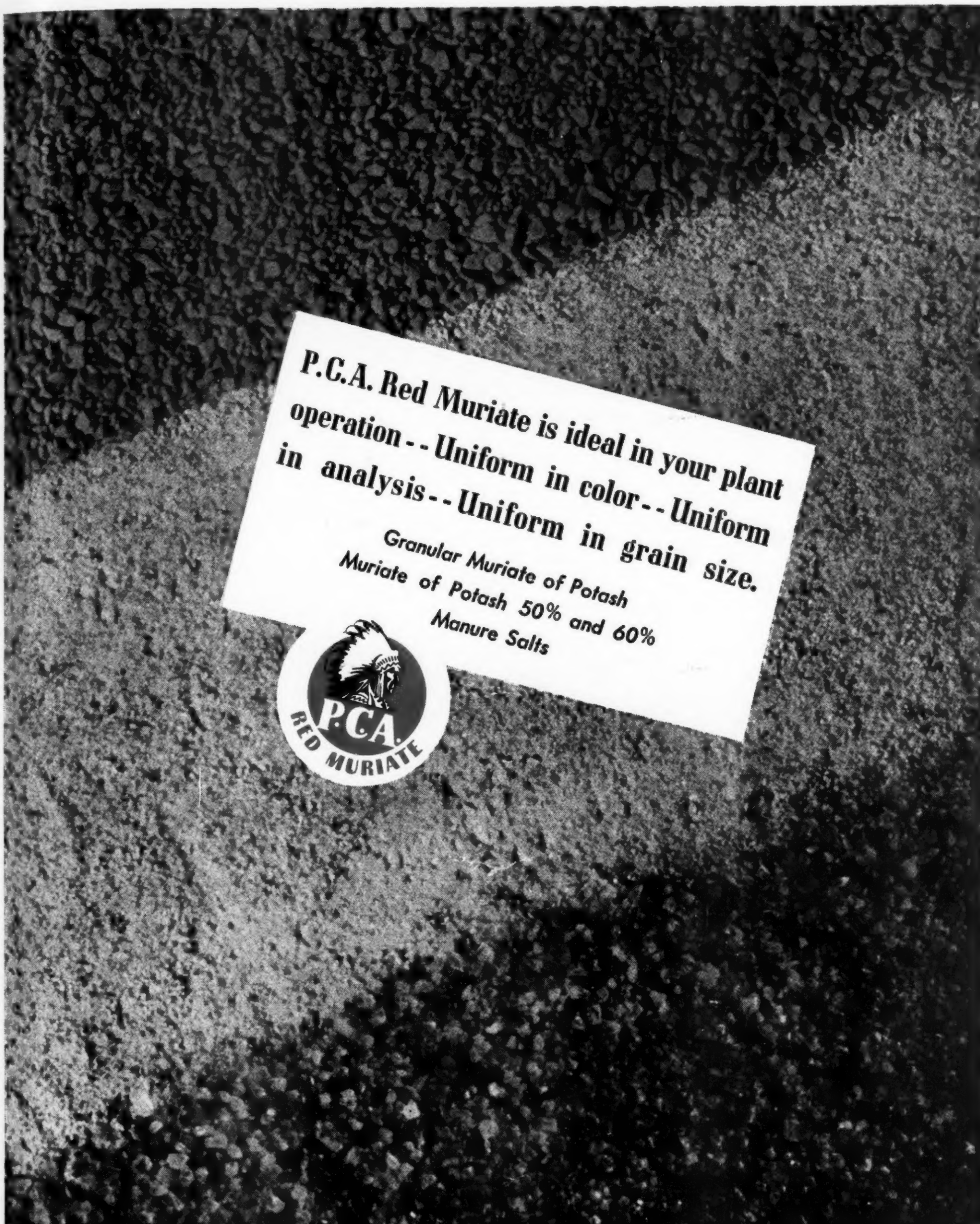
P.C.A. Red Muriate is ideal in your plant operation - - Uniform in color - - Uniform in analysis - - Uniform in grain size.
Granular Muriate of Potash
Muriate of Potash 50% and 60%
Manure Salts
P.C.A.
RED MURIATE